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DESIGN AND EVALUATION OF VISIBILITY SENSOR/RUNWAY VISUAL RANGE --ETC(U)
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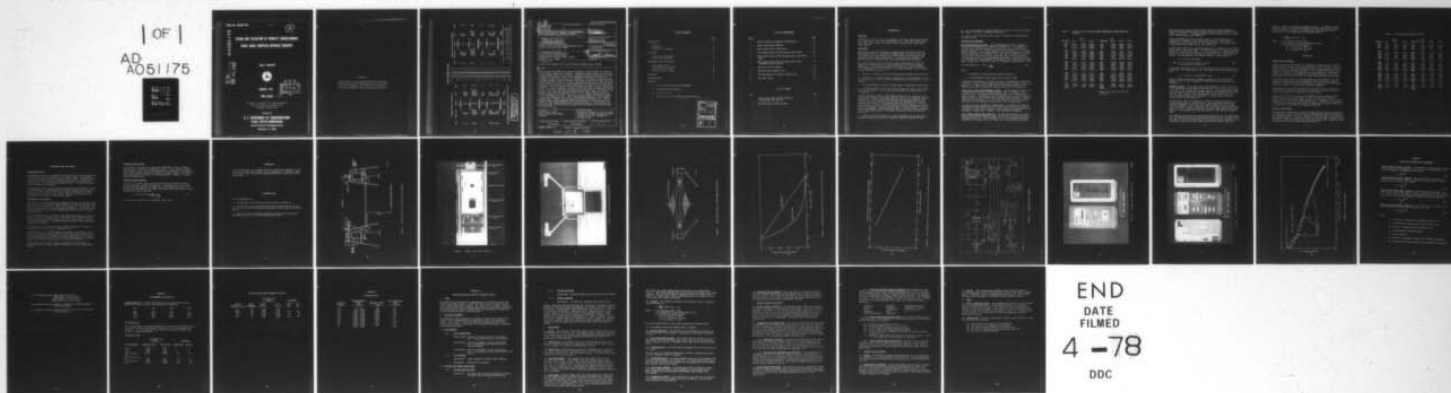
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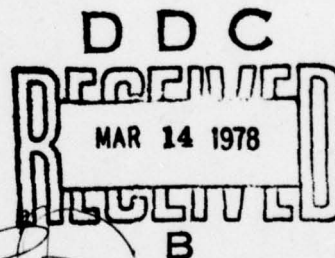
**DESIGN AND EVALUATION OF VISIBILITY SENSOR/RUNWAY
VISUAL RANGE COMPUTER INTERFACE CIRCUITRY**

James E. Newcomb



JANUARY 1978

FINAL REPORT



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METRIC CONVERSION FACTORS

| Approximate Conversions to Metric Measures | | | |
|--|------------------------|--------------------------|------------------------|
| Symbol | When You Know | Multiply by | To Find |
| LENGTH | | | |
| in | inches | 2.5 | centimeters |
| ft | feet | 30 | centimeters |
| yd | yards | 0.9 | meters |
| mi | miles | 1.6 | kilometers |
| AREA | | | |
| in ² | square inches | 6.5 | square centimeters |
| ft ² | square feet | 0.09 | square meters |
| yd ² | square yards | 0.8 | square meters |
| mi ² | square miles | 2.6 | square kilometers |
| | acres | 0.4 | hectares |
| MASS (weight) | | | |
| oz | ounces | 28 | grams |
| lb | pounds | 0.45 | kilograms |
| | short tons (2000 lb) | 0.9 | tonnes |
| VOLUME | | | |
| tsp | teaspoons | 5 | milliliters |
| Tbsp | tablespoons | 15 | milliliters |
| fl oz | fluid ounces | 30 | milliliters |
| c | cup | 0.24 | liters |
| pt | pints | 0.47 | liters |
| qt | quarts | 0.96 | liters |
| gal | gallons | 3.8 | liters |
| ft ³ | cubic feet | 0.03 | cubic meters |
| yd ³ | cubic yards | 0.76 | cubic meters |
| TEMPERATURE (exact) | | | |
| °F | Fahrenheit temperature | 5/9 after subtracting 32 | Celsius temperature |
| °C | Celsius temperature | 9/5 then add 32 | Fahrenheit temperature |

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Mon. Publ. 285, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.16286.

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| 16. Abstract Runway visual range (RVR) is an aviation visibility value obtained by utilizing a special purpose signal data converter. Atmospheric transmittance, one of the processing parameters used, is provided by a National Bureau of Standards type transmissometer that samples clarity of the atmosphere by measuring the amount of incandescent light from a known source remaining in the beam after passing through a baseline distance of 500 or 250 feet. New types of visibility sensors are now being produced that operate on a light-scattering principle rather than attenuation. These new types of sensors are being considered as alternatives to the NBS transmissometer. If found suitable, these new sensors will require signal conditioning circuitry in order to operate in conjunction with existing, standard-type RVR computers. This report describes the design and testing of such an interface circuit to permit use of the EG&G model 207 Forward Scatter Meter (FSM) with the RVR computer. The output of the FSM is an 0 - 5 V d.c. analog voltage proportional to the scattering coefficient. This circuit design changes the analog voltage to a pulse train with pulse rate, width, and amplitude comparable to the standard transmissometer output. Circuit design was validated by system tests. The new design produced computer-displayed RVR values equivalent to those normally provided by an NBS transmissometer. It was concluded that the circuit design does provide accurate interface between the EG&G model 207 FSM and FA-7871-type signal data converters. | | |
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INTRODUCTION

OBJECTIVE.

The purpose of this activity is to develop an interface circuit which converts the output signal of the EG&G International, Inc., model 207 Forward Scatter Meter (FSM) into a signal acceptable for the standard runway visual range (RVR) computer.

BACKGROUND.

Human observations of fixed-distance targets is the traditional method of determining visibility. Problems in standardization of reports arise from this method due to differences in the visual acuity between observers and variations in the visual target itself. To overcome these problems, the National Bureau of Standards (NBS) type transmissometer was developed.

For aviation applications, the Federal Aviation Administration (FAA) has adopted the transmissometer as the sole sensor for providing fog density measurements to fixed-purpose computers for conversion to RVR information. The transmissometers are considered to be reliable equipment, but are subject to some limitations, such as:

1. Frequent attention is required for maintaining alignment and calibration.
2. Outages due to component failure sometimes occur during periods of restricted visibility, yet, until recently, recalibration was only possible in clear weather.
3. The transmissometer circuitry (vacuum tubes) is approaching obsolescence.
4. Installation and siting criteria are not easily met, due to size, weight, and need for rigidity. It can not be used to satisfy all sensor location requirements.

In 1969, Cambridge Systems of EG&G began construction of a new type of visibility sensor through a development contract with Air Force Cambridge Research Laboratories. The new sensor, FSM model 207, measured the amount of light scattered out of the main beam after impinging on atmospheric particles to determine the clarity of the atmosphere and hence the visibility. The FSM was developed to fulfill a need for numerous visibility observations about an airport. Its design seemed to eliminate many of the shortcomings of the NBS-type transmissometer. Consideration was given to using the FSM as an alternative to the transmissometer. Two primary factors were under consideration by the FAA:

1. Would use of the FSM sensor as a direct replacement for the NBS transmissometer significantly alter the aviation visibility parameter of RVR?

2. Can the FSM sensor be mated by interface circuitry directly to existing RVR computers in order to minimize system costs?

The scope of effort detailed in this report is confined to consideration of the latter factor.

DESCRIPTION OF EQUIPMENT.

NBS TRANSMISSOMETER (FA-7861). The transmissometer (figure 1) measures opacity of the atmosphere or atmospheric transmittance. The instrument is a double-ended system consisting of a stable light source directed to a sensitive photoelectric receiver separated from the projector by a selected baseline distance. After passing through this baseline distance with attenuation by hydrometers or lithometers, the light energy remaining in the beam is converted at the receiver to an electrical pulse train with frequency linearly proportional to the atmospheric transmittance. Regardless of baseline distance, the transmissometer is adjusted so that 4,000 pulses per minute (ppm) is equivalent to perfectly clear air (atmospheric transmittance = 1.0).

The relationship is:
$$t_x = \frac{f}{4,000} \quad (1)$$

where:

t_x = atmospheric transmittance per baseline distance x

f = transmissometer signal pulse train frequency in ppm

Atmospheric transmittance per baseline distance is exponentially related to an observer's target visual distance only after certain assumptions have been made as to the nature of the target and its background luminance. These assumptions and their mathematical treatment are outlined in appendix A.

RUNWAY VISUAL RANGE (RVR) COMPUTER (FA-7871). The RVR computer (figure 2) is a fixed-purpose system that computes values of RVR in accordance with equations 3 and 4 of appendix A and provides remote user locations with a digital display. While several types of computers are in current usage, all commonly depend on the following input parameters for operations: (1) runway edge light step settings 3, 4, or 5 as the light source, (2) day or night luminance, and (3) atmospheric transmittance from a transmissometer.

The computer accepts atmospheric transmittance in the form of ppm from the transmissometer and displays RVR values from 600 to 6,000 feet in reported increments of either 200 or 500 feet. Table 1 shows the relationship of the atmospheric transmittance increment to the reported RVR increment.

EG&G FORWARD SCATTER METER, MODEL 207. The EG&G FSM determines the visual range by measuring the amount of light scattered in the forward direction by atmospheric particles. The FSM (figure 3) is a self-contained instrument, consisting of a projector unit, receiver unit, and associated electronics.

TABLE 1. RUNWAY VISUAL RANGE (RVR) VERSUS ATMOSPHERIC TRANSMITTANCE PER 250 FEET

| RVR (ft) | NIGHT | | | RVR (ft) | DAY | | |
|----------|--------|--------|--------|----------|---------|---------|---------|
| | LS 5 | LS 4 | LS 3 | | LS 5 | LS 4 | LS 3 |
| 600- | | | | 600- | | | |
| 600 | .00134 | .00299 | .00670 | 600 | .02995 | .06696 | .14973 |
| 800 | .01128 | .02003 | .03560 | 800 | .10376 | .18436 | .32757 |
| | .03513 | .05493 | .08589 | | .19740 | .30867 | .44679* |
| 1000 | | | | 1000 | | | |
| 1200 | .07074 | .10198 | .14702 | 1200 | .29045 | .41873 | .51727 |
| 1400 | .11338 | .15451 | .21056 | 1400 | .37461 | .51050 | .57248 |
| 1600 | .15897 | .20788 | .27184 | 1600 | .44787 | .58566 | .61668 |
| 1800 | .20477 | .25946 | .32874 | 1800 | .51072 | .64710 | .65277 |
| | .24916 | .30793 | .38056 | | .56443 | .68274* | .68274 |
| 2000 | | | | 2000 | | | |
| 2200 | .29128 | .35279 | .42730 | 2200 | .61040 | .70802 | .70802 |
| 2400 | .33073 | .39396 | .46928 | 2400 | .64990 | .72960 | .72960 |
| 2600 | .36742 | .43158 | .50694 | 2600 | .68401 | .74823 | .74823 |
| 2800 | .40139 | .46589 | .54076 | 2800 | .71362 | .76448 | .76448 |
| | .43277 | .49718 | .57117 | | .73948 | .77877 | .77877 |
| 3000 | | | | 3000 | | | |
| 3500 | .48199 | .54552 | .61741 | 3500 | .77742 | .80003 | .80003 |
| 4000 | .54149 | .60282 | .67110 | 4000 | .81945 | .82418 | .82418 |
| 4500 | .59064 | .64929 | .71377 | 4500 | .84315* | .84315 | .84315 |
| 5000 | .63166 | .68749 | .74827 | 5000 | .85843 | .85843 | .85843 |
| | .66623 | .71929 | .77659 | | .87100 | .87100 | .87100 |
| 5500 | | | | 5500 | | | |
| 6000 | .69566 | .74608 | .80016 | 6000 | .88152 | .88152 | .88152 |
| 6000+ | .72094 | .76888 | .82001 | 6000 | .89046 | .89046 | .89046 |
| | | | | 6000+ | | | |

*Values below this point based on contrast.

The projector unit emits a high-intensity, modulated light (mechanically chopped at 292 hertz (Hz) which is electronically monitored to obtain a constant lamp intensity. A cone-shaped beam of light is projected over a range of 50°, with the center 20° masked out.

Located approximately 4 feet from the projector is the receiver unit. A photodetector contained in the receiver unit detects the light that is scattered in its direction from the cone-shaped volume. The sample volume, a torus-shaped space (figure 4), is 1.67 cubic feet.

The FSM output signal is an analog voltage which is calibrated to be inversely proportional to the visual range. The linear output of the instrument ranges from 0 to 5 volts direct current (d.c.), corresponding to a visual range from 2,000 feet to 200 feet with overrange provision to 7 volts corresponding to 32 feet. The relationship of the output voltage to visual range is:

$$V_o = 5 \text{ volts} \times 200 \text{ feet}/D$$

Where: V_o is the output voltage in volts, (2)
D is the visual range in feet

An optional logarithmic output of the FSM increases the visual range up to 20,000 feet. The relationship of the logarithmic output to the visual range is:

$$V_o = 5/2 \text{ volts} \times \log (20,000 \text{ feet}/D). \quad (3)$$

Figure 5 shows the FSM output voltages as related to the visual range, assuming a 0.05 contrast threshold of visibility and using equation 1 of appendix A.

INTERFACE CIRCUIT. An interface circuit was designed to convert the 0- to 7-volt logarithmic output signal of the FSM into a pulse train, proportional to visibility and acceptable to the RVR computer. The FSM logarithmic output option was chosen, because the extended range better encompasses FAA requirements for RVR. Figure 6 shows this graphically, and figure 7 shows the circuitry design schematic to accomplish it. Figures 8 and 9 show the circuit boards which accomplish it.

The FSM output signal was summed with a reference voltage to produce a d.c. voltage proportionate to the visibility. This voltage was digitized for optimum transmission of the data. To optimize transmission of the signal across any length of land or telephone line, an existing commercial unit was used to convert the digital signal into a frequency shift keying (FSK) transmission. At the receiver unit, the FSK signal is converted into a digital word.

The interface circuit further converted the digital word into an analog voltage. The analog voltage is further examined by the receiver interface circuit to sense two voltage threshold levels for determining three constants of proportionality used in the final stage conversion of voltage to RVR pulse

frequency through the voltage-to-frequency converter. A monostable multivibrator is used to obtain the RVR computer required pulse width, and this pulse is amplified to obtain the required pulse output voltage level of -12 volts d.c. The equation of the interface circuit is:

$$f = K \frac{\text{ppm}}{\text{volt}} (5.65 \text{ volts} - V_o) \quad (4)$$

where: f is frequency output in ppm.
 V_o is logarithmic output of EG&G FSM in volts.
 K is constant of proportionality:-
 $V_o < 3.5$ volts; $K = 840$
 $V_o 3.5 - 4.0$ volts; $K = 660$
 $V_o > 4.0$ volts; $K = 420$

DISCUSSION

OPERATIONAL REQUIREMENTS.

Ideally, the reported RVR should be a measurement through the pilot's entire visual distance involved. Such is not the case, due to the lack of state-of-the-art advances in single-ended equipment such as laser backscatter devices. Instead, the present working technique is to use a measurement over a fixed baseline and extrapolate the measurement on the assumption of homogeneity of atmosphere. Because the atmosphere is very seldom homogenous, differences arise between the RVR reported and the visual range perceived by the pilots.

In a similar vein, because of this nonhomogeneity of atmosphere, any rigid comparison between sensor types operating on different baseline lengths or different locations will result in different, yet equally correct RVR computations with respect to the specific fog density sampling.

Superimposed on these sampling differences is another type of difference in visual distance perception resulting from individual variations in retinal illuminance thresholds of sensitivity to light targets.

These types of differences cannot be accommodated by any standard computational system, such as an RVR computer, and it has become acceptable to consider two RVR measurements under comparison as being equal if they are not different by more than one reported RVR increment. In addition, any potential RVR replacement sensor should be capable of measuring fog density ranging from the equivalent of RVR 6,000 feet to less than 600 feet.

TECHNICAL REQUIREMENTS.

The operational requirements of reporting resolution and range can be obtained by inspection of table 1 and applied to the FSM operating voltage characteristics through equations 3 and A-1. Results are shown in table 2 and graphically depicted in figure 10. Interface circuitry for the FSM signal conversion should be designed towards duplicating the curve shown in figure 10, although any curve falling within error band limits would be acceptable.

TABLE 2. RVR-FSM VOLTAGE CONVERSION TABLE

| RVR (ft) | NIGHT | | | RVR (ft) | DAY | | |
|----------|-------|------|------|----------|------|------|------|
| | LS 5 | LS 4 | LS 3 | | LS 5 | LS 4 | LS 3 |
| 600- | 5.62 | 5.48 | 5.32 | 600- | 4.93 | 4.65 | 4.26 |
| 600 | 5.20 | 5.05 | 4.87 | 600 | 4.45 | 4.14 | 3.69 |
| 800 | 4.88 | 4.72 | 4.54 | 800 | 4.09 | 3.74 | 3.33 |
| 1000 | 4.62 | 4.46 | 4.27 | 1000 | 3.80 | 3.42 | 3.11 |
| 1200 | 4.41 | 4.24 | 4.05 | 1200 | 3.55 | 3.14 | 2.98 |
| 1400 | 4.23 | 4.06 | 3.85 | 1400 | 3.33 | 2.89 | 2.78 |
| 1600 | 4.07 | 3.89 | 3.68 | 1600 | 3.13 | 2.66 | 2.64 |
| 1800 | 3.92 | 3.74 | 3.53 | 1800 | 2.96 | 2.52 | 2.52 |
| 2000 | 3.79 | 3.61 | 3.39 | 2000 | 2.80 | 2.41 | 2.41 |
| 2200 | 3.68 | 3.49 | 3.26 | 2200 | 2.65 | 2.31 | 2.31 |
| 2400 | 3.57 | 3.38 | 3.15 | 2400 | 2.52 | 2.22 | 2.22 |
| 2600 | 3.47 | 3.27 | 3.04 | 2600 | 2.39 | 2.14 | 2.14 |
| 2800 | 3.37 | 3.18 | 2.94 | 2800 | 2.27 | 2.06 | 2.06 |
| 3000 | 3.22 | 3.02 | 2.77 | 3000 | 2.07 | 1.94 | 1.94 |
| 3500 | 3.04 | 2.83 | 2.57 | 3500 | 1.81 | 1.78 | 1.78 |
| 4000 | 2.87 | 2.65 | 2.39 | 4000 | 1.65 | 1.65 | 1.65 |
| 4500 | 2.72 | 2.50 | 2.22 | 4500 | 1.53 | 1.53 | 1.53 |
| 5000 | 2.59 | 2.36 | 2.07 | 5000 | 1.42 | 1.42 | 1.42 |
| 5500 | 2.47 | 2.33 | 1.94 | 5500 | 1.32 | 1.32 | 1.32 |
| 6000 | 2.35 | 2.12 | 1.81 | 6000 | 1.23 | 1.23 | 1.23 |
| 6000+ | | | | 6000+ | | | |

PERFORMANCE TESTS AND RESULTS

ENVIRONMENTAL TESTS.

Environmental tests within manufacturer's specifications were performed on the EG&G FSM to determine the stability of the output signal. The laboratory calibrator was used to obtain a reference output voltage. Parameters varied to test the unit were temperature, relative humidity, line voltage, and line frequency. The unit was also subjected to an ice buildup to determine the effectiveness of the heaters.

During initial setup, it was noticed that incandescent lamps had an effect on the output signal. Illumination from a variable frequency strobe light was projected in the vicinity of the receiver unit to determine the possible susceptibility to external light sources. Appendix B contains the tests performed and the variation of the output signal.

ENVIRONMENTAL TEST RESULTS.

The results of the environmental tests demonstrated that this EG&G FSM tested did not meet the manufacturer's specifications. The greatest variation from expected output voltage (value read at room temperature) occurred while subjecting the instrument to -30 centigrade (C) temperature. The linear output voltage deviated 11 percent and the logarithmic output deviated 6 percent during this test.

It was observed that the deviation of the output signal during all tests, was greatest in the linear output scale. Variation of line frequency and line voltage produced no significant variation in the output signal. The EG&G output signal responded to incandescent lights (60 Hz) and light modulated at subharmonics of 292 Hz.

The response of the FSM produced large erroneous readings with respect to visibility while subjecting it to modulated light.

During the course of the environmental tests listed in appendix B, it was noticed that initial and final values of FSM signal output voltage were not stable or repeatable. For example, during the temperature tests, the log output varied from 3.360 to 3.671 V d.c. This corresponds to an equivalent variation in RVR (LS 5 night, table 2) from 2,600 to 2,000 feet.

Additional sensors should be tested to determine if this deficiency is representative of the sensor design or is intrinsic to this single sensor tested.

INTERFACE CIRCUIT TESTS.

The accuracy of the interface circuit was determined by using a variable voltage source to simulate the FSM output signal. Using a digital voltmeter and frequency counter, the following parameters were obtained: (1) voltage input, (2) equivalent visibility of EG&G, (3) frequency output to RVR computer, and (4) equivalent visibility of the transmissometer. Appendix C contains results of these tests.

INTERFACE CIRCUIT RESULTS.

The interface circuit between the EG&G FSM and the RVR computer produced accurate readings from 600- to 6,000+ feet. Comparison of the visual range between the transmissometer and interface circuit showed that the circuit was accurate from 1/16 mile to 1 mile. All results were found using a variable voltage source and the equation:

$$V_o = 5/2 \text{ volts } \log \frac{20,000}{D} \text{ feet} \quad (3)$$

D (feet)

to convert the voltage into an equivalent visual range.

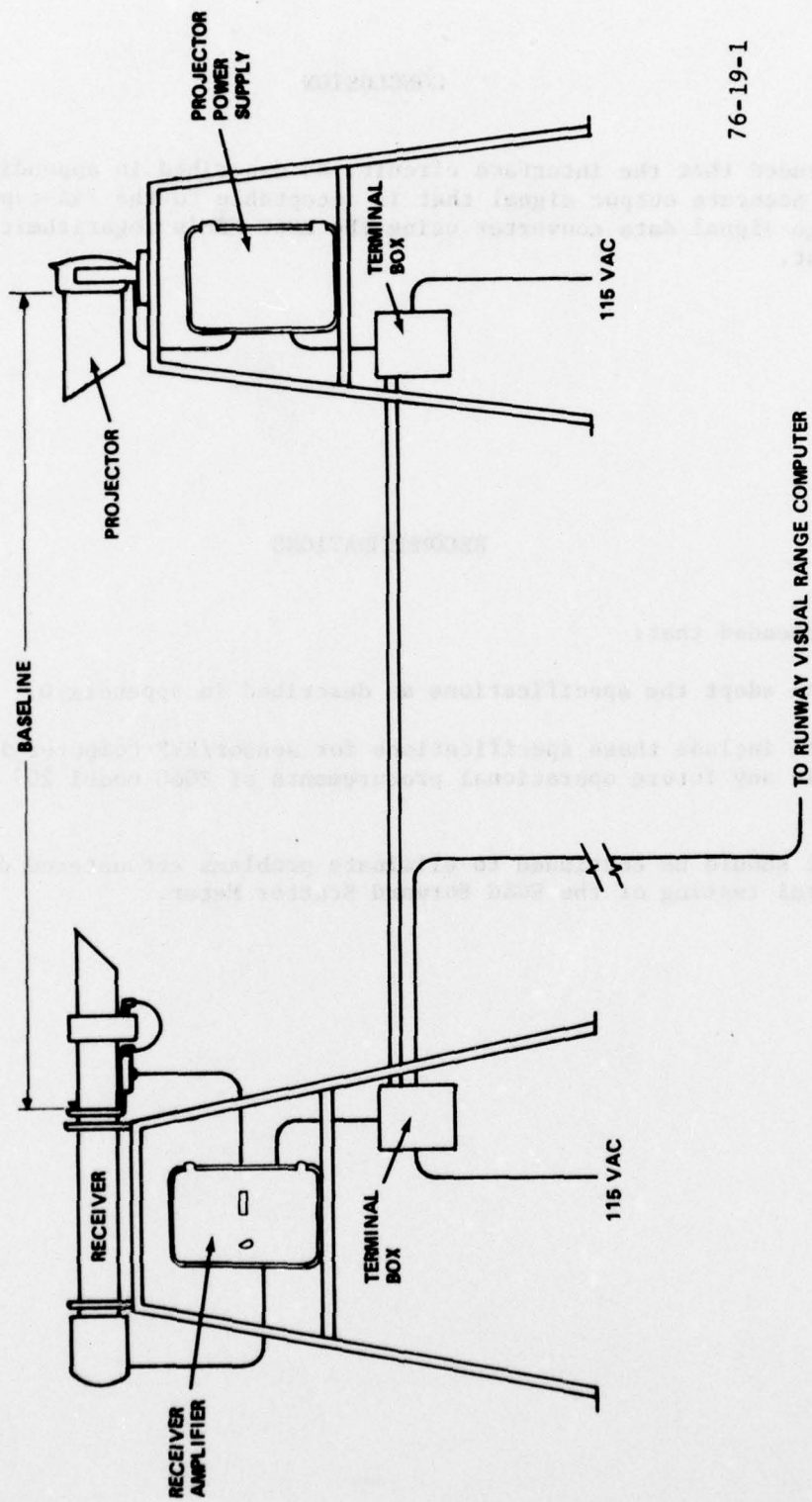
CONCLUSION

It is concluded that the interface circuit, as described in appendix D, does provide an accurate output signal that is acceptable to the FAA-type runway visual range signal data converter using the EG&G FSM's logarithmic output as its input.

RECOMMENDATIONS

It is recommended that:

1. The FAA adopt the specifications as described in appendix D.
2. The FAA include these specifications for sensor/RVR computer interface circuitry in any future operational procurements of EG&G model 207 visibility meters.
3. Effort should be continued to eliminate problems encountered during environmental testing of the EG&G Forward Scatter Meter.



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FIGURE 1. NATIONAL BUREAU OF STANDARDS TRANSMISSOMETER

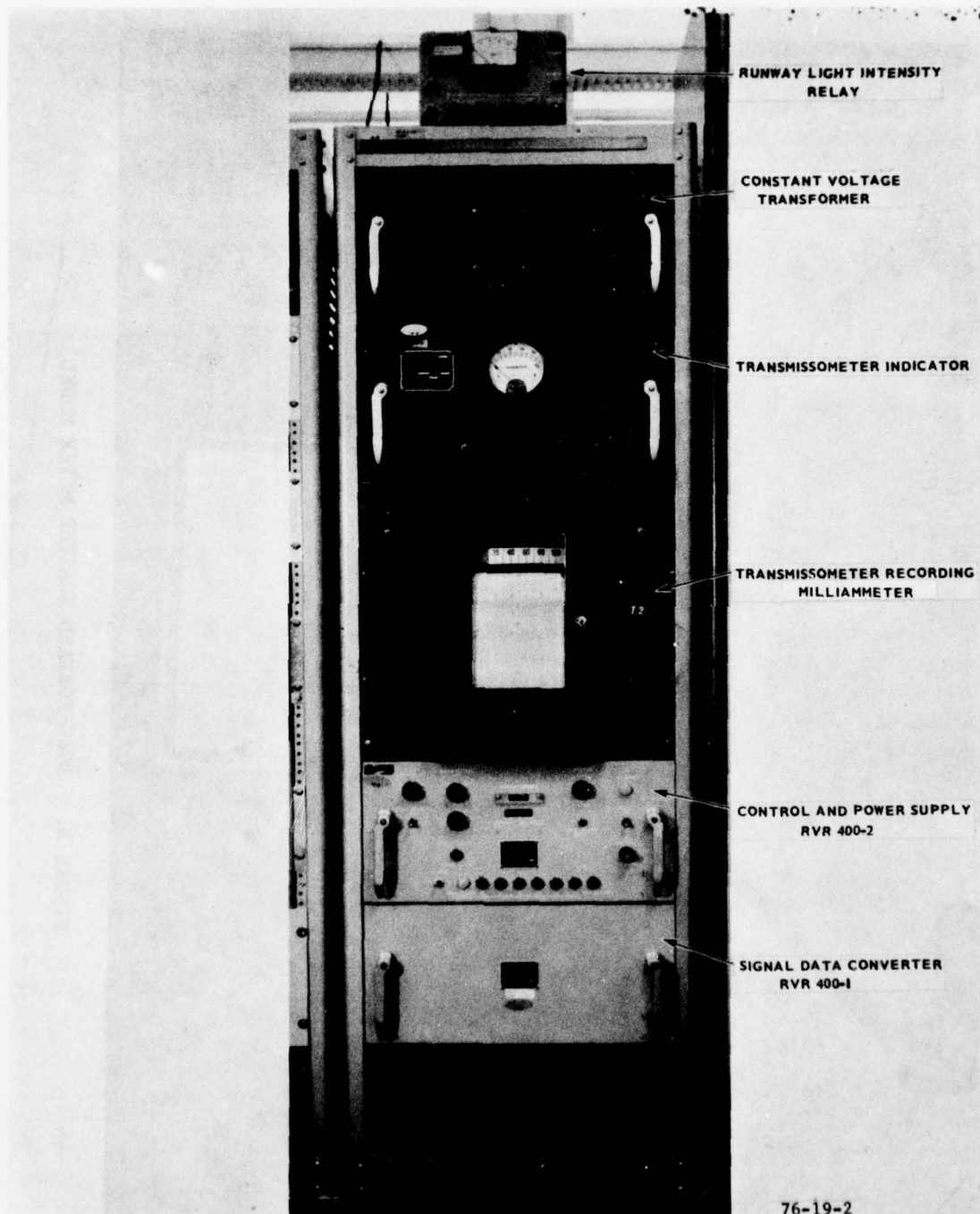


FIGURE 2. RUNWAY VISUAL RANGE COMPUTER

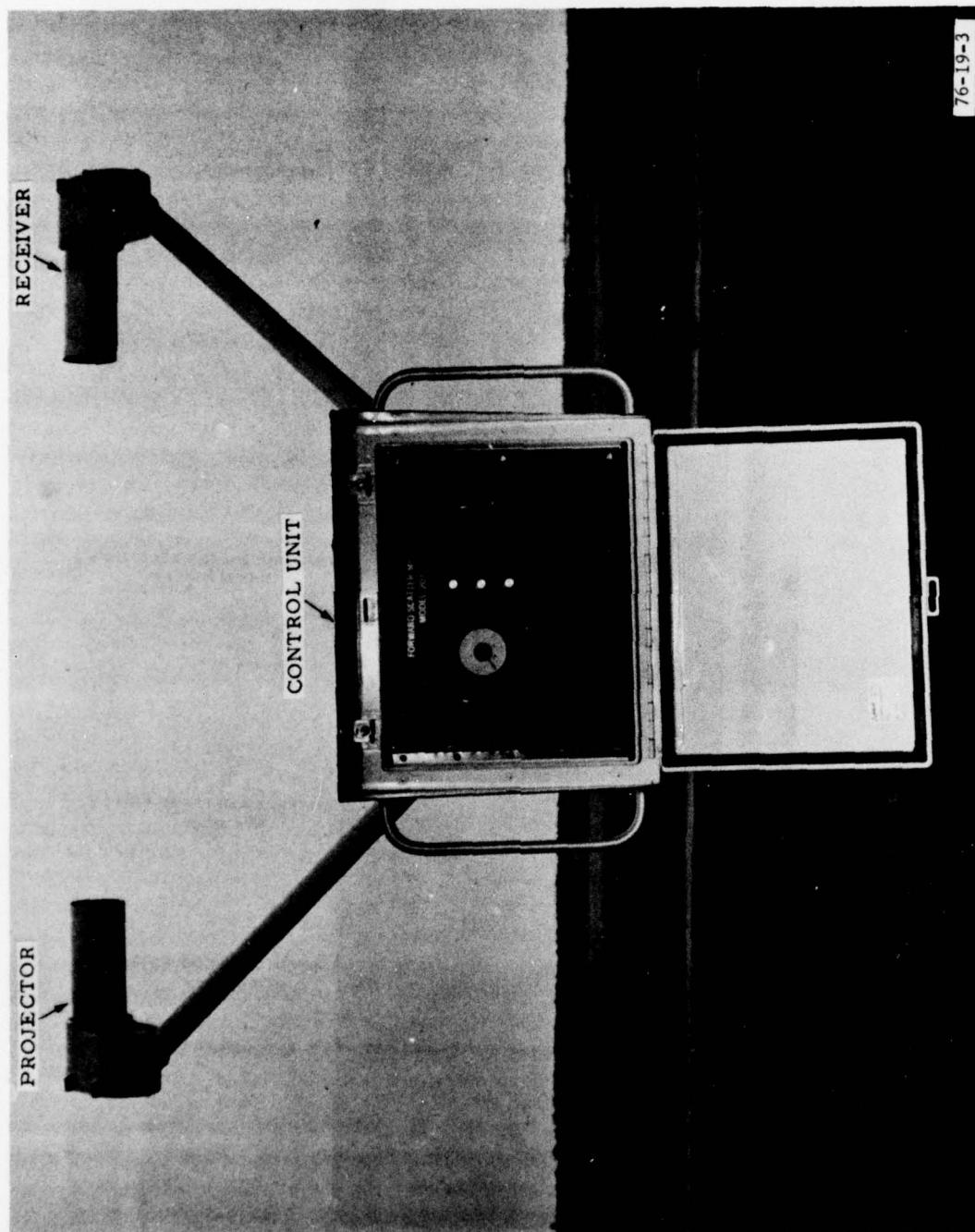


FIGURE 3. EG&G FORWARD SCATTER METER MODEL

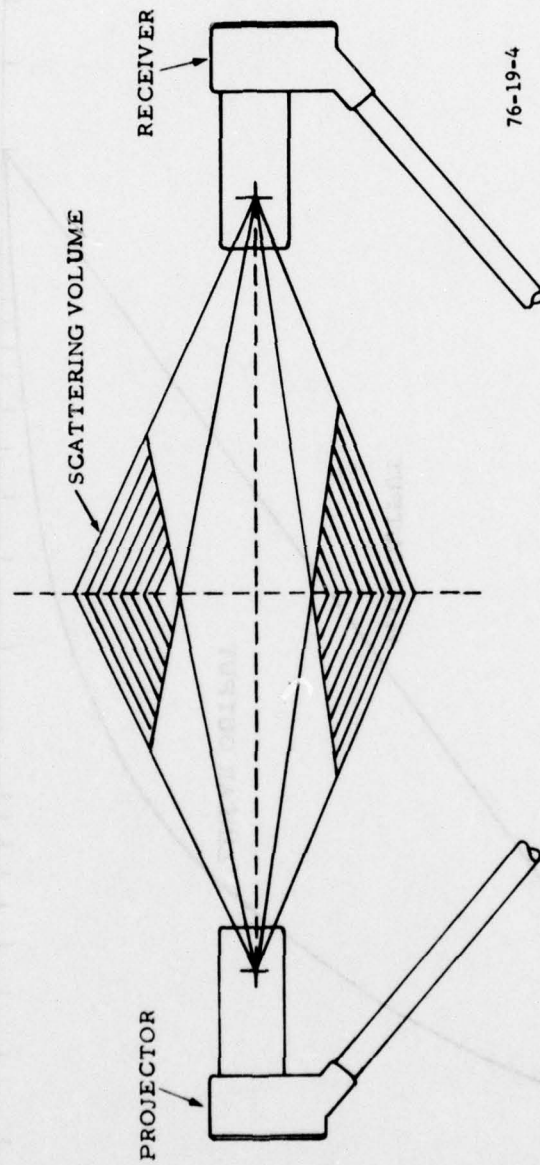


FIGURE 4. TORUS SAMPLING AREA OF EG&G FORWARD SCATTER METER

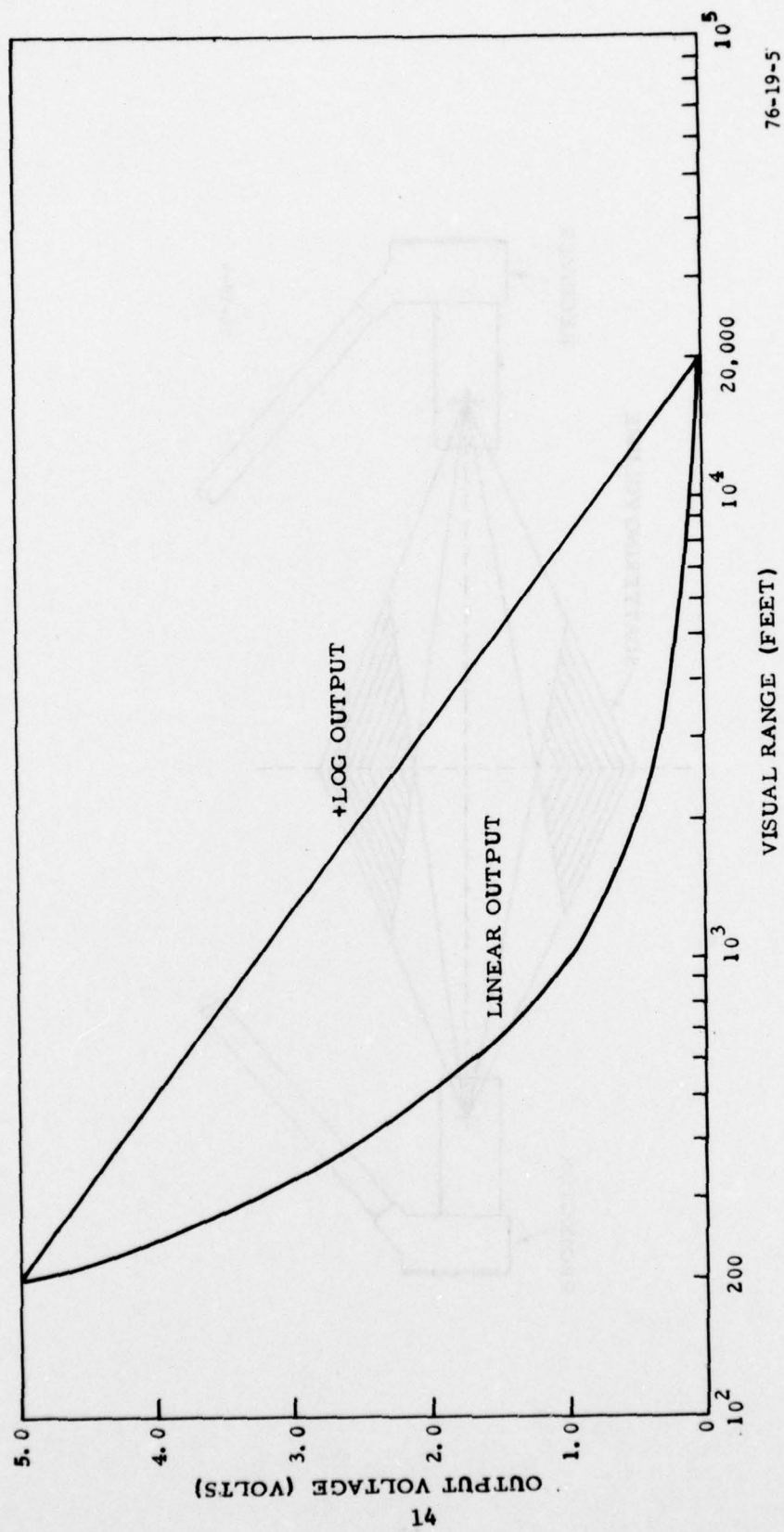


FIGURE 5. EG&G FORWARD SCATTER METER VOLTAGE OUTPUT VERSUS VISUAL RANGE

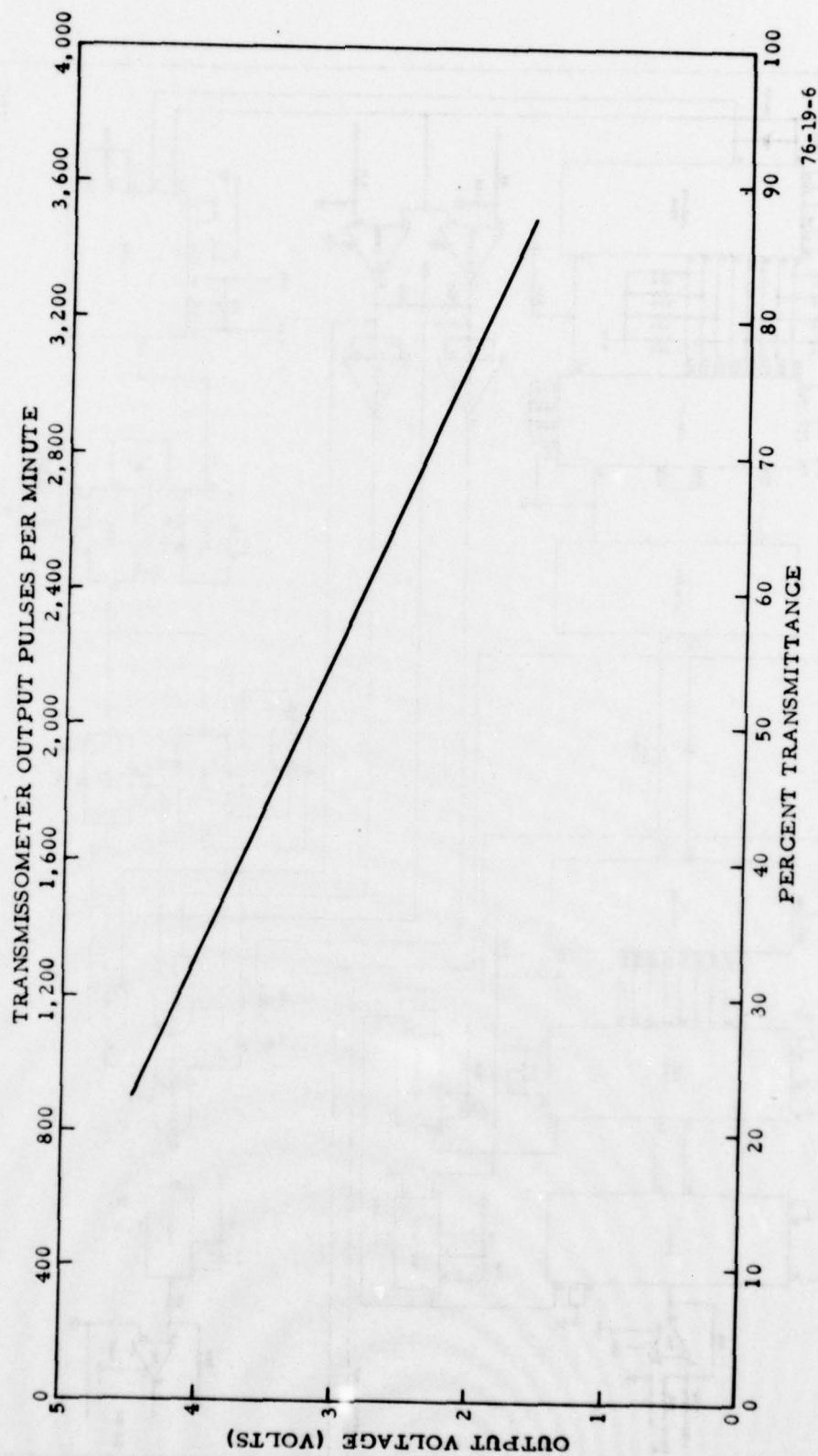


FIGURE 6. EG&G FORWARD SCATTER METER VOLTAGE OUTPUT VERSUS TRANSMITTANCE PER 250 FEET

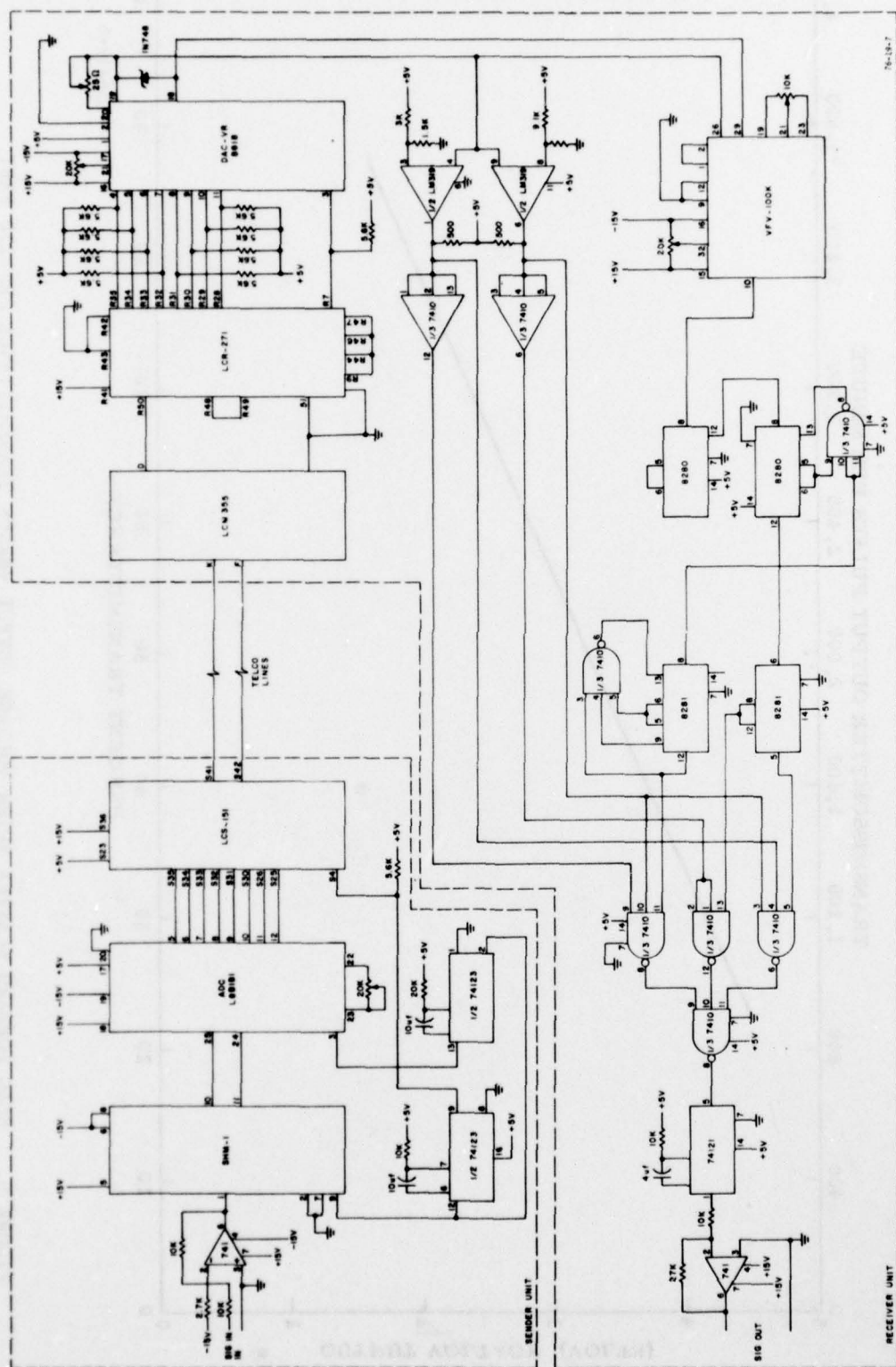


FIGURE 7. INTERFACE CIRCUIT SCHEMATIC

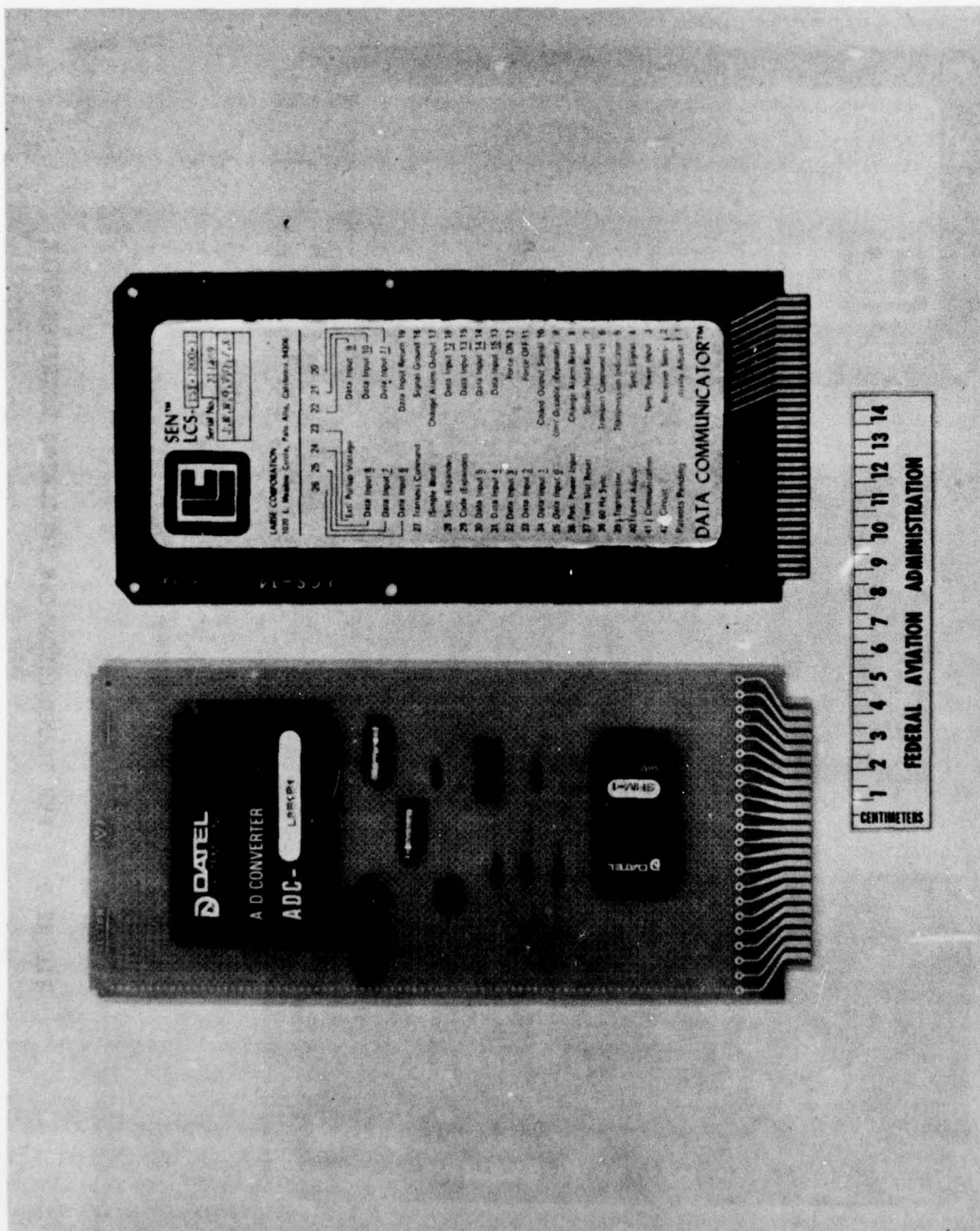
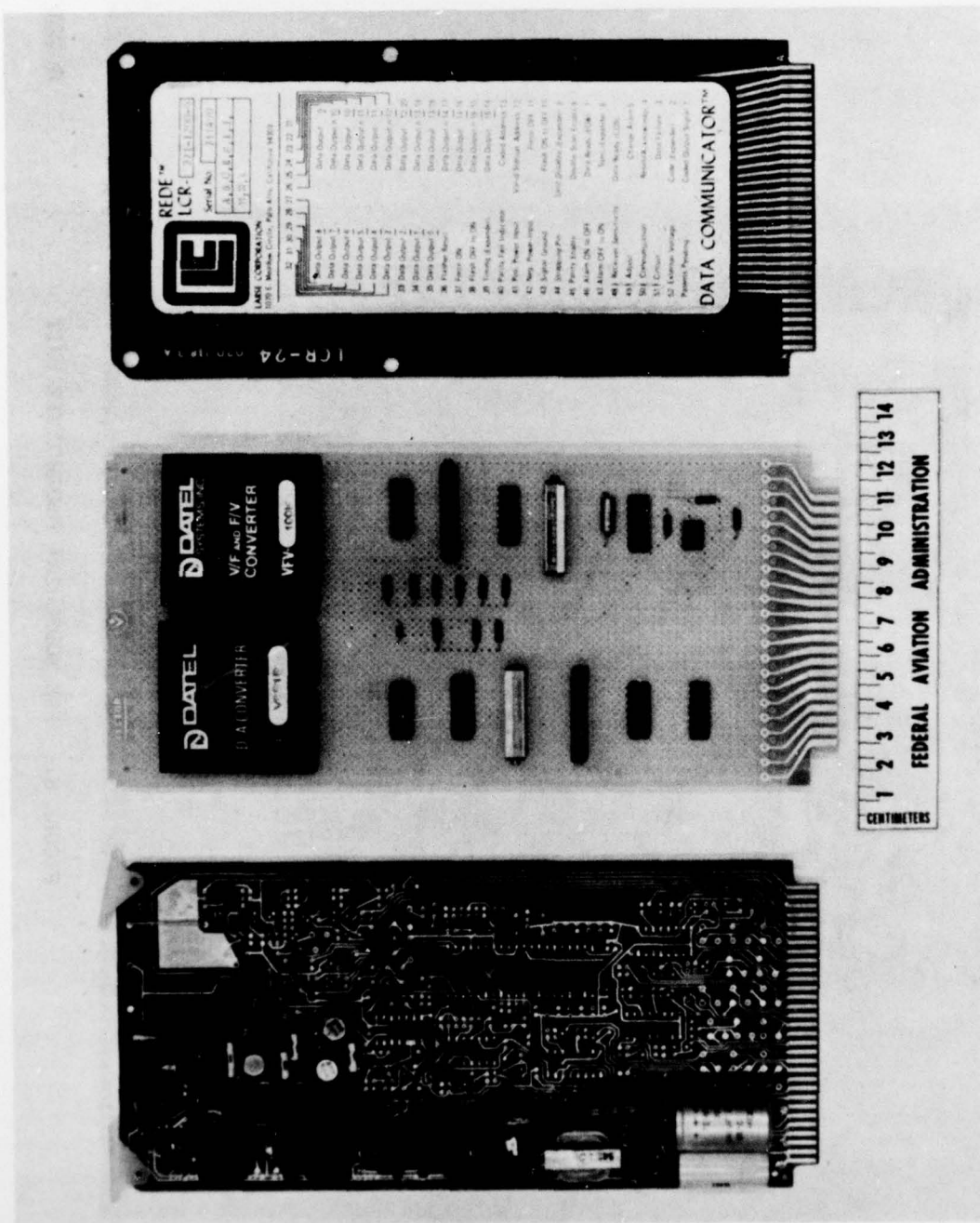


FIGURE 8. FSM MODEL 207 TRANSMITTER UNIT

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FIGURE 9. RVR TRANSMISSOMETER INDICATOR RECEIVER UNIT

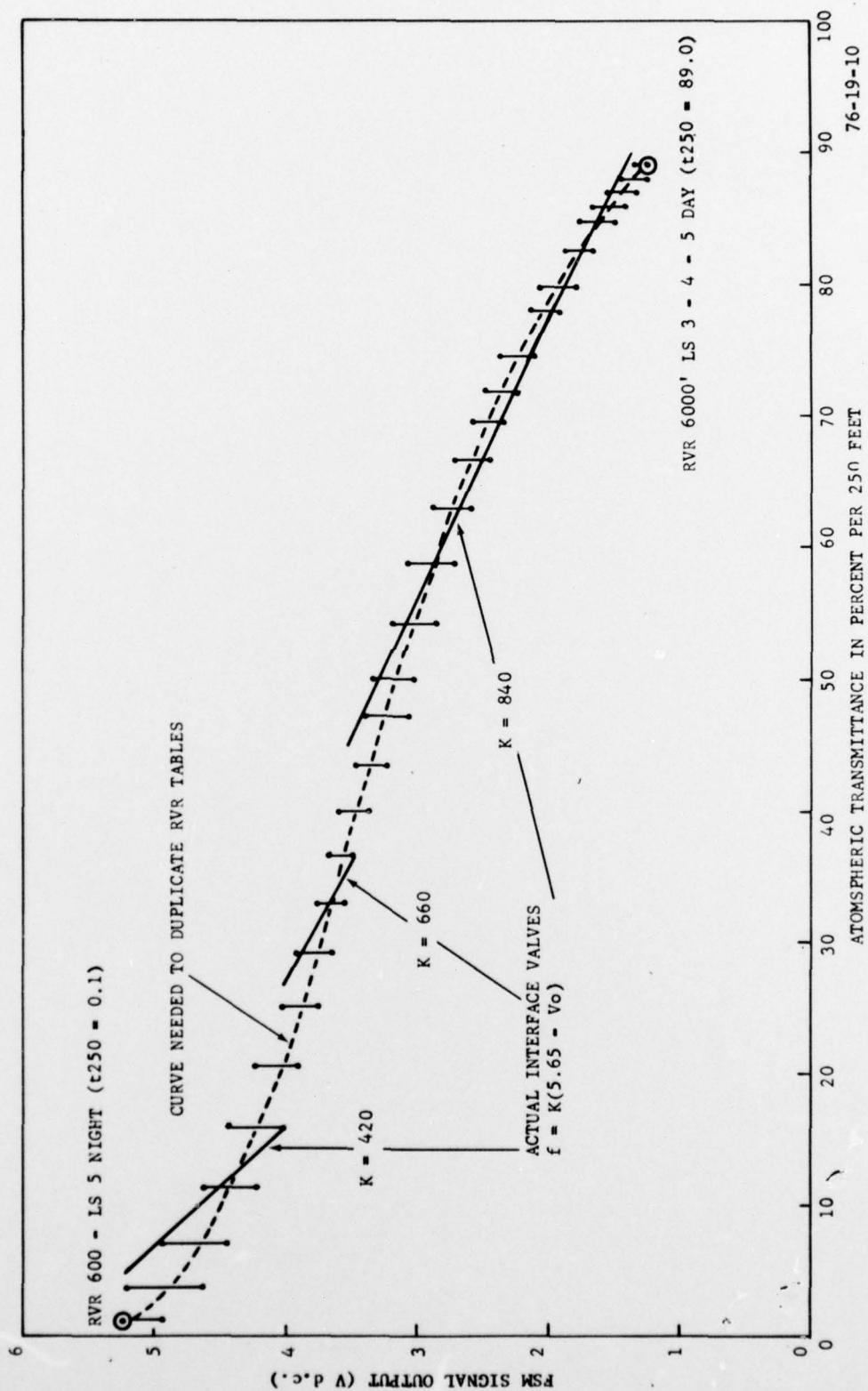


FIGURE 10. FSM SIGNAL OUTPUT

APPENDIX A

VISUAL RANGE DEFINITIONS AND TREATMENT

Runway Visibility (RVV) - Daytime. The observer's visual target is assumed to be an object of such size and color that it can be viewed against its daytime background. Koschmieder's Law is used:

$$t_x = (E_o)^{b/D} \quad (A-1)$$

Runway Visibility (RVV) - Nighttime. The visual target is assumed to be a low-to-moderate-intensity (about 25 candelas) unfocused light at night. A modified form of Allard's Law is used:

$$t_x = \frac{S_v \cdot D^{b/D}}{I_m} \quad (A-2)$$

Runway Visual Range (RVR) - Daytime. The visual target is assumed to be a high-intensity runway edge light or runway contrast (texture, paint, border, etc.). When solution to equation A-1 yields a greater visual distance, the equation A-1 solution takes precedence, otherwise Allard's Law is used:

$$t_x = \frac{E_d \cdot D^{2b/D}}{I_h} \quad (A-3)$$

Runway Visual Range (RVR) - Nighttime. The visual target is assumed to be a high-intensity runway edge light. Allard's Law is used:

$$t_x = \frac{E_n \cdot D^{2b/D}}{I_h} \quad (A-4)$$

where:

t_x = atmospheric transmittance per baseline distance "x"

f = transmissometer signal pulse train frequency in ppm

E_o = observer's luminal contrast threshold of .050

b = transmissometer baseline distance

D = visual distance

S_v = observer's illuminance threshold of 1.584×10^{-5} lumens/feet

I_m = representative moderate target light intensity of 25 candelas

I_h = representative high target light intensity of
400 candelas at step setting 3
2,000 candelas at step setting 4
10,000 candelas at step setting 5

E_d = observer's daytime illuminance threshold of 3.59×10^{-5} lumens/ft²
(1,000 mile-candelas)

E_n = observer's nighttime illuminance threshold of 7.17×10^{-8} lumens/ft²
(2 mile-candelas)

APPENDIX B

ENVIRONMENTAL TEST RESULTS

STROBED LIGHT TEST. The EG&G logarithmic output voltage varied from the steady state level +2 volts at the frequencies listed below:

| (Hz) | (Hz) | (Hz) | (Hz) |
|-------|------|------|------|
| 293.7 | 58.8 | 32.7 | 22.7 |
| 146.7 | 49.0 | 29.3 | 21.0 |
| 97.8 | 42.0 | 26.7 | 19.7 |
| 72.8 | 36.7 | 24.5 | 18.3 |

ICE BUILDUP TEST.

The two strip heaters (optional equipment) were installed on the EG&G projector and receiver housings, and attempts to build up ice on the instrument were commenced. No ice accumulated in the vicinity of the heater, and the unit was able to continue operating.

TEMPERATURE TESTS

| <u>TEST CONDITIONS</u> | <u>EG&G MODEL 207 OUTPUT</u> | | <u>DEVIATION</u> | |
|------------------------------------|--------------------------------------|---------------------|-------------------|----------------|
| | <u>LINEAR (V d.c.)</u> | <u>LOG (V d.c.)</u> | <u>LINEAR (%)</u> | <u>LOG (%)</u> |
| 22.5° C | 1.256 | 3.463 | | |
| -30° C | 1.398 | 3.671 | 11 | 6 |
| +50° C | 1.168 | 3.360 | 7 | 2 |
| +50° C @ 98% RH | 1.83 | 3.382 | 5.8 | 2.3 |
| 22.5° 36 hours after RH Test | 1.291 | 3.505 | 2.8 | 1.2 |
| +1° C @ 98% RH | 1.194 | 3.448 | 4.9 | .43 |
| 22.5° C | 1.276 | 3.484 | 1.6 | .61 |

LINE VOLTAGE AND LINE FREQUENCY VARIATION

| APPLIED VOLTAGE (V a.c.) | LINE FREQUENCY | EG&G MODEL 207 OUTPUT | | DEVIATION | |
|-----------------------------|-------------------|--------------------------|-----------------|---------------|------------|
| | | LINEAR (V d.c.) | LOG (V d.c.) | LINEAR (%) | LOG (%) |
| 115 | 60 | 1.268 | 3.486 | | |
| 103.5 | 60 | 1.266 | 3.485 | 0.15 | 0.02 |
| 126.5 | 60 | 1.270 | 3.487 | .15 | .02 |
| 115 | 57 | 1.250 | 3.468 | 1.42 | .52 |
| 115 | 63 | 1.284 | 3.496 | 1.26 | .29 |

APPENDIX C
INTERFACE TESTS

| <u>VISIBILITY</u> <u>(miles)</u> | <u>TRANSMISSOMETER</u> <u>OUTPUT</u> <u>(ppm)</u> | <u>INTERFACE CIRCUIT</u> <u>(ppm)</u> | <u>EG&G LOGARITHMIC</u> <u>OUTPUT</u> <u>(Volts)</u> |
|-------------------------------------|---|--|--|
| 1/16 | 52 - 924 | 899 | 4.46 |
| 1/8 | 928 - 1,660 | 1,590 | 3.7 |
| 3/16 | 1,664 - 2,136 | 1,990 | 3.26 |
| 1/4 | 2,140 - 2,456 | 2,272 | 2.95 |
| 5/16 | 2,460 - 2,684 | 2,490 | 2.71 |
| 3/8 | 2,688 - 2,924 | 2,672 | 2.51 |
| 1/2 | 2,928 - 3,128 | 2,954 | 2.2 |
| 5/8 | 3,132 - 3,296 | 3,172 | 1.96 |
| 3/4 | 3,280 - 3,380 | 3,354 | 1.76 |
| 7/8 | 3,384 - 3,456 | 3,499 | 1.6 |
| 1 | 3,384 - 3,456 | | 1.45 |

APPENDIX D

SPECIFICATIONS FOR VISIBILITY INTERFACE CIRCUIT

1. SCOPE.

This specification sets forth the requirements for an interface circuit that converts the output signal of a visibility sensor into an acceptable signal for the runway visual range computer. The circuit shall be capable of accepting an analog signal that is inversely proportional to visibility, transmitting this signal over voice-grade telephone lines, and converting the signal into a pulse train proportional to the visibility.

2. APPLICABLE DOCUMENTS.

The following pertinent documents on the date of Request for Proposals form a part of this specification and are applicable to the extent specified herein. In the event of conflict between the documents referenced herein and this specification, the contents of this specification shall be considered a superseding requirement.

2.1 FAA DOCUMENTS.

2.1.1 FAA SPECIFICATIONS.

- FAA-G-2100/1B Electronic Equipment, general requirements;
Part 4, basic requirements for all equipment.
- FAA-G-2100/4B Electronic Equipment, general requirements;
Part 4, requirements for employing Printed
Wiring Techniques
- FAA-G-2100/5A Electronic Equipment, general requirements;
Part 5, requirements for employing Microelectronic
Devices.

2.1.2 FAA STANDARDS.

- FAA-STD-010 Graphic Symbols for Digital Logic Diagrams
- FAA-STD-013 Quality Control Program

2.2 MILITARY AND FEDERAL PUBLICATIONS

2.2.1 MILITARY SPECIFICATION.

- MIL-E-17555 Electronic and Electrical Equipment, Accessories
and Repair Parts; Packaging and Packing of

2.2.2 MILITARY STANDARDS.

MIL-STD-188 Military Communication System Technical Standards

2.2.3 FEDERAL STANDARDS.

FED-STD-102 Preservation, Packaging, and Packing Levels.

Copies of applicable FAA specifications and standards may be obtained from the Federal Aviation Administration, Washington, D.C. 20591, Attention: Contracting Officer. Requests should fully identify material desired, i.e., specification standards and amendment, numbers and dates. Requests should cite the contract number or other use to be made of the requested material. Single copies of the military specifications and Standards may be obtained from Federal Aviation Administration, Washington, D.C. 20591, Attention: Contracting Officer. Requests should cite invitation for bids, requests for proposals, or contract involved. Note: mail requests, if found acceptable, will be forwarded to a military supply depot for filling; hence, ample time should be allowed.

3. REQUIREMENTS.

3.1 SYSTEM. The visibility instrument interface circuit shall consist of one transmit unit and one receive unit. This system shall be capable of operation at a distance of at least 10 miles using ordinary single voice-grade telephone wires. The equipment must have exceptional reliability and provide easy maintenance by plug-in modules.

3.2 TRANSMIT UNIT. The transmit unit shall be so designed so that it will mount in a space of 8 inches by 6 inches by 2 inches. The unit shall contain a power terminal and an input and output signal terminal.

3.3 RECEIVE UNIT. The receive unit shall be so designed that it will mount in a space of 12 inches by 8 inches by 6 inches. The unit shall contain a power input terminal and an input and output terminal. This unit shall contain a power switch on the front panel.

3.4 POWER REQUIREMENTS. The transmit unit shall operate from +15 volts, -15 volts, and +5 volts. That transmit unit shall require no more than 0.5 amperes (A) of input current. The receive unit shall operate from 104 to 127 V a.c. at a frequency of 57 to 63 Hz. The receive unit shall require no more than 5 A of input current. The receive unit shall be with an a.c. power cable and plug in accordance with FAA G-2100/1, paragraph 1-3.10.2, 5 feet long. In addition, each unit shall contain any other power supplies necessary for its operation.

3.5 DATA SIGNAL. The data signal output from the transmit unit shall be of definite format and shall be capable of being transmitted over a single pair of voice-grade telephone lines for a distance of at least 25 nmi and shall be capable of being received by the receive unit and converted into a digital word at a rate of 1-second intervals. The receive unit output signal shall be such that it is approximately a 12 V a.c. pulse, 10 milliseconds wide as received by the runway visual range computer.

The receive unit output signal shall be such that it is approximately a 12 V a.c. pulse, 10-milliseconds wide and received by the runway visual range computer. The data signal shall be transmitted from the transmit unit at least once a second and be capable of being received by the receive unit to convert until next signal is received.

3.6 ACCURACY. The visibility interface circuit shall provide a frequency output equivalent to:

$$f = K \frac{\text{ppm}}{\text{volt}} (5.65 \text{ volts} - V_o)$$

where: f is frequency output in ppm.
 V_o is logarithmic output of EG&G FSM in volts.
 K is constant of proportionality:
 $V_o < 3.5$ volts; $K = 840$
 $V_o 3.5 - 4.0$ volts; $K = 660$
 $V_o > 4.0$ volts; $K = 420$

The output should deviate no more than 5 percent from expected value.

3.7 Two complete instruction manuals shall be supplied.

3.8 AMBIENT CONDITIONS. The equipment shall be designed for operation in ambient conditions of Environment II Specification FAA-G-2100/1, paragraph 1-3.2.23.

3.9 MEAN TIME BETWEEN FAILURES. Unit failure shall be defined as any occurrence, apart from loss of primary power, which requires corrective action. Mean time between failure of interface circuit shall not be less than 10,000 hours.

3.10 MAINTAINABILITY. The system shall be designed with as few moving parts as possible.

The electrical and mechanical design shall provide for minimum maintenance, with all components readily accessible.

3.11 INTERCHANGEABILITY. Any system component shall be interchangeable with any other system component of the same type. Any system shall remain within specifications when any system component is interchanged with any corresponding component from another system.

3.12 SOLID STATE CIRCUITRY. No vacuum tubes shall be used in the system. Solid state circuitry shall be used throughout. Printed wiring boards shall be employed with Specification FAA-G-2100/1, FAA-G-2100/3, and FAA-G-2100/4.

3.13 INTEGRATED CIRCUITRY. Only integrated circuits available as standard catalog items from two or manufacturers shall be employed. The circuits may be employed with FAA approval.

3.14 PROVISION FOR CALIBRATION. Provisions shall be included in the system to permit recalibration by FAA with FAA equipment over a suitable voltage range at the site. The instruction book shall include specific instructions as to how this calibration shall be performed, describing equipment required (including suggested type numbers and methods employed).

4. QUALITY ASSURANCE PROVISIONS.

4.1 QUALITY CONTROL PROVISIONS. The contractor shall provide and maintain a quality control program in accordance with FAA-STD-013. All tests and inspection made by contractor shall be subject to government inspection. The term "government inspection," as used in this specification, means that an FAA representative will witness the contractor's testing and inspection and will carry out such visual and other inspection as deemed necessary to assure compliance with contract requirements. Classes of tests are required as listed below.

4.2 CONTRACTOR'S PRELIMINARY TESTS. Prior to the time the contractor notifies the government that the initial production system is ready for inspection, and in order to demonstrate readiness for inspection, he shall make one complete set of all tests required by this specification. These preliminary tests shall be made on one production system or on one prototype (preproduction) model. The contractor's preliminary tests do not constitute any of the regular design qualification tests, type tests, or production tests required by the equipment specification or by the referenced general specifications.

4.2.1 PRELIMINARY TEST DATA. The contractor shall submit to the government contracting officer a certified copy of the test data covering all of the contractor's preliminary tests. These test data may be submitted along with the proposed test procedures and terms under FAA-STD-013, but in any case, the test data shall be submitted not less than 10 working days in advance of the data set for inspection pursuant to paragraph 4.2.2.

4.2.2 NOTIFICATION OF READINESS FOR INSPECTION. After submission of the preliminary test data, and when the contractor has one or more production systems completed, i.e., equipments produced to meet all specification requirements, he shall notify the government contracting officer in writing that he is ready for government inspection. Such notification shall be given in time to reach the contracting officer no less than five workdays before the contractor desires inspection to start.

4.3 DESIGN QUALIFICATION TESTS. The following tests (and verification) shall be made on a regular production system selected by the government contracting officer: (1) rating verification parts and materials (4.3.1), (2) other general specification tests (4.3.2), (3) design qualification tests in this specification.

4.3.1 RATING VERIFICATION PARTS AND MATERIALS. Measurements or calculations, or both, shall be made in order to establish that the electrical and electro-mechanical parts, wire, and insulating material used in the equipment will not be subjected to voltages, currents, power dissipation, and temperature in excess of the rated values permitted by this specification. The following is a basic list of parts and materials to which the foregoing applies. (Other electrical and electro-mechanical parts used in the system shall also be subjected.)

| | | |
|---------------------|--------------|-----------------------|
| Capacitors | Resistors | Semiconductor Devices |
| Crystals | Switches | (Transistors, Diodes, |
| Fuses | Transformers | Rectifiers, etc.) |
| Insulators | Wire | |
| Insulating Material | Connectors | |

4.3.2 OTHER GENERAL SPECIFICATION TESTS. Tests shall be made in order to establish that the requirements of the following paragraphs of FAA-G-2100/1, wherever applicable, are being met:

- (1) Discharge of capacitors (1-3.5.5),
- (2) Ground potentials (1-3.5.9.1 to 1-3.5.9.3),
- (3) A.C. line input resistance to ground (1-3.6.3)
- (4) Service conditions of temperature and humidity
- (5) Circuit protection (at minimum line voltage in service conditions (range) (1-3.9),
- (6) Performance requirements and tolerances specified in parts 3, 4, and 5 of FAA-G-2100/1, where such parts are applicable.

4.3.3 SPECIAL DESIGN QUALIFICATION TESTS. The tests of the visibility interface circuit shall be conducted by the contractor at a site or facility approved by and in the presence of a government inspector. Error shall be determined by comparison of input voltage and runway visual range output with known tables.

5. PREPARATION FOR DELIVERY.

5.1 GENERAL. Preservation, packing, and marking shall be in accordance with the requirements of Specification MIL-E-1755 (see 6.2). Level of protection as defined in Federal STD-102 shall be as specified by the procuring activity (see 6.2).

5.2 PRESERVATION AND PACKING. Each system complete with two sets of instruction books shall be individually preserved and packaged in accordance with Level A or C requirements of Specification MIL-E-173-55 (see 6.2). Each packaged system shall be individually marked for identification and stocking. Equipment within each packaged unit shall be preserved to that extent necessary to insure shipment with no damage.

5.3 PACKING. Items preserved and packaged as above, shall be packed in exterior containers, selected from appropriate tables of MIL-EL7555, conforming to the applicable levels of packing specified (see 6.2). The shipping containers shall be marked in accordance with procurement documents.

6. NOTES.

6.1 NOTE ON INFORMATION ITEMS. The paragraphs below are only for the information of the contracting officer and the requisitioning office intended to assist in formulating a contract. They are not contract requirements, not binding on either the government or the contractor, except to the extent that they may be specified elsewhere in the contract as such. Any reliance placed by the contractor on the information in these subparagraphs is wholly at contractor's own risk.

6.2 ORDERING DATA. Requests, requisitions, schedules, and contracts on orders should specify the following:

- (1) Title, number, and date of this specification,
- (2) The number of the components to be supplied,
- (3) The location for the testing of the initial unit,
- (4) The level of preservation and packaging required, and
- (5) The level of packing required.